Improvements in or relating to reciprocating compressors

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Inventor(s):
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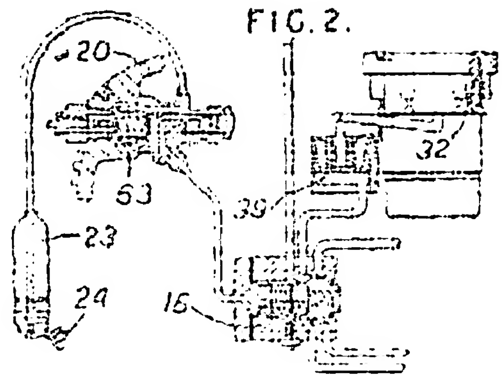
Abstract of **GB 733511 (A)**

733,511. Fluid-pressure servomotor control systems. CARRIER ENGINEERING CO., Ltd. March 30, 1953 [Sept. 6, 1952], No. 8799/53. Class 135. In a system for controlling the capacity of a reciprocating compressor, more especially for refrigerating plant, as described in Specification 654,451, and comprising a valve 20 sensitive to compressor load as detected by intake pressure and controlling a distributing valve 16 which directs oil under pressure sequentially to spring- loaded pistons 39 associated with each cylinder and coacting with abutments 32 for holding open the compressor inlet valves, the response of the system to change of load is retarded by transmitting the intake pressure to the pressuresensitive element 63 of the valve 20 through a capillary tube 24 and surge chamber 23. The capillary tube opens to the compressor crankcase, which is at intake pressure, below the level of lubricating oil therein. The lower part of the surge chamber 23 contains oil and the upper part refrigerant gas.

FIG. 2.



PATENT SPECIFICATION

733,511

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COMPLETE SPECIFICATION

Improvements in or relating to Reciprocating Compressors

We, CARRIER ENGINEERING COMPANY LIMITED, a Company incorporated under the laws of Great Britain, of 24, Buckingham Gate, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to reciprocating compressors and more particularly to a capacity control for a reciprocating compressor for refrigeration systems, controlled by a valve responsive to load conditions.

A main object of the present invention is to prevent rapid recycling during operation of the compressor by retarding response of the capacity control valve to changes in load imposed upon this system.

In the specification of Patent No. 654,451, there is disclosed a system of capacity control for reciprocating compressors which includes oil pressure actuated elements for holding compressor valves in inoperative position, an oil pressure actuated member for permitting or discontinuing the passage of oil to the elements and a valve responsive to load conditions for varying the oil pressure imposed on the oil pressure actuated member to permit or to discontinue the supply of oil to the elements in sequence in accordance with load conditions.

According to the invention a capacity control for a reciprocating compressor comprises a fluid pressure actuated element for holding a compressor valve in inoperative position, fluid pressure actuated means for permitting or discontinuing the pasasge of fluid to said element, means responsive to load conditions for varying the fluid pressure imposed on the fluid pressure actuated means to permit or to discontinue the passage of fluid to said element in accordance with load conditions, and a control for retarding the response of said means to changes in load conditions, said retarding control comprising a trapped surge chamber, means including a restricted orifice connecting the chamber with a source of oil pressure which varies in accordance with changes in load, e.g., the crank case of the compressor below the oil level therein, and a line connecting the surge chamber with the load responsive means to actuate the same.

The means responsive to load conditions may be subjected to fluid pressure substantially equivalent to the suction pressure of the compressor. The means connecting the chamber with a source of oil pressure may comprise a capillary tube.

A pump may be provided to supply lubricant to moving parts of the compressor, and a line may connect the pump to the sump of the compressor, the means which include the restricted orifice being connected to said line. The surge chamber may contain refrigerant gas.

The invention also includes a capacity control of the kind above referred to for a reciprocating compressor having two or more cylinders each having a fluid pressure actuated element in association therewith, the fluid pressure actuated means comprising a first valve permitting or discontinuing the passage of fluid to the elements of the two or more cylinders in sequence, and the load responsive means comprising a second valve for varying the fluid pressure imposed on the first valve.

In order that the invention may be better understood a preferred embodiment thereof will now be described by way of example, as applied to a refrigeration system, with reference to the accompanying drawing, in which:

Fig. 1 is a diagrammatic view illustrating a compressor including a capacity control according to the present invention; and

Fig. 2 is an enlarged diagrammatic view of the capacity control.

[Price 3/-]

In the drawings, the same references designate the same parts.

Referring to the drawing, there is shown in Fig. 1 a compressor 2 having a plurality of cylinders, 3, 4, 5 and 6. The compressor may be of any conventional design and includes a crank case 7, the bottom of which serves as an oil sump 8, and operating mechanism including the usual crank shaft 9, pistons 10, connecting rods 11, and other structural elements normally employed in compressing gas, all of which form no essential part of the invention, but which it will be understood are present to form an operable compressor.

Suitable unloading mechanism designated generally at 12 is provided to hold the suction valve 13 of a cylinder in an operative or inoperative position. Mechanism 12 may be actuated by means of a power element 14 actuated by oil pressure. Any desired number of cylinders of the compressor may be provided with unloading mechanism.

A pump 15 provides lubrication for the moving parts of the compressor. A control valve 16 is connected to the pump 15 by a line 17. A relief valve 18 is placed in line 17 to maintain a constant oil pressure to the moving parts of the compressor and to the valve 16. The valve 16 is connected to the various power elements 14 by means of lines 19, and serves to permit or to discontinue the supply of oil to each power element 14 in sequence, that is, one after the other as hereinafter described. A capacity control valve 20 is connected to valve 16 by means of line 21 and serves to regulate or adjust valve 16 as hereinafter described. Valve 20 is connected to the sump 8 through line 22, surge chamber 23, capillary tube 24, and oil line 25. Such elements form retarding mechanism to delay response of control valve 20 as hereinafter described. Oil may be drained from valve 20 to sump 8 through line 26.

The capacity control is disposed in the pump end cover 27 of compressor 2.

The unloading mechanism 12 consists of lifter sleeve 31, lifter pins 32, loading springs 33, and a retaining ring 34. Suction gas from the manifold (not shown) enters suction valve port 35 and passes through such port into the interior of the compressor cylinder when valve 13 is moved away from port 35. When pins 32 are in the position illustrated in Fig. 2, the suction valve 13 closes at the end of each suction stroke under the urging of springs (not shown). After compression of the gas in this cylinder, the gas is discharged through discharge valves (not shown) into the cylinder head space. Pins 32 remain retracted while full oil pressure is applied to power element 14 and are moved upward to hold valve 13 in inoperative position when oil pressure on element 14 is discontinued. Power element 14 consists of a casing 36 having a base 37 and a top cover 38. Piston 39 is placed in casing 36 and is connected by a rod 40 to a forked lever 41, operating on a fulcrum 42 placed at one end of cover 38. Lever 41 terminates in portions 43 adapted to engage the lifter sleeve 31 surrounding the cylinder. A piston spring 44 applies predetermined pressure to piston 39. In the absence of oil pressure supplied to element 14, piston 39 rests against the bottom cover 37. A vent 45 is provided in power element 14 to permit oil which seeps past piston 39 to return to the crank case 7 of compressor 2. Preferably, the power elements 14 are located in the suction manifold of the compressor adjacent the cylinder to be unloaded.

When oil pressure is applied to element 14, piston 39 moves upward permitting lever 41 to pivot about fulcrum 42 thus permitting sleeve 31 to be urged downward by springs 33 until such movement is halted by contact of sleeve 31 against ring 34. Downward movement of sleeve 31 carries pins 32 therewith thus permitting suction valve 13 to be disposed in inoperative position. When pressure is removed from power element 14 as by, for example, discontinuing the passage of oil thereto, piston 39 is forced downward by spring 44, pivoting lever 41 about fulcrum 42 and urging sleeve 31 in an upward direction to raise pins 32 thus holding valve 13 away from port 35 with the suction valve placed in an open position. No compression of gas takes place in the cylinder and the capacity of cylinder in zero.

Valve 16 is an oil-pressure actuated, multiple port, snap action piston valve. Oil pressure is supplied to a chamber 50 of valve 16 through line 17. Piston 51 is placed in chamber 50. Piston 51 is provided with grooves 52. A spring 53 is held in chamber 50 by cap 54 to provide a predetermined pressure to urge piston 51 longitudinally of chamber 50. The end of piston 51 serves in effect as a partition separating or dividing chamber 50 from a second chamber 56. End opening 57 in end 55 connects chamber 50 and 56. Chamber 56 is connected to capacity control valve 20 by line 21.

A plurality of outlets 58 are provided in chamber 50 and are connected to lines 19 leading to the various power elements 14. An opening 59 is formed in the casing of valve 16. A spring 60 is placed in opening 59 and urges a ball member 61 into one of the grooves 52 in piston 51.

Valve 20 includes a chamber 62 in which is placed a bellows 63. Bellows 63 is subjected on one side to fluid pressure substantially equivalent to suction pressure through inlet 64. On its opposite side, bellows 62 is placed under a predetermined force asserted by spring *64a*; such side of the bellows is

also subject to atmospheric pressure.

A port 65 is provided in valve 20 adapted to be closed by a valve member 66, in this case, a needle. Push rods 67 convey movement of bellows 63 to member 66. Oil is admitted to the valve, entering through inlet 68 from line 21 connecting valve 20 with chamber 56 of valve 16. When port 65 is opened by movement of needle 66, oil is free to flow through the port and through outlet 69 and line 26 to the crank case of the compressor. An auxiliary spring 70 operates in opposition to the adjustment spring to eliminate lost motion in the mechanism and to permit operation in a vacuum range of suction pressures.

Fluid pressure is provided to one side of bellows 63 through line 22 connecting control valve 20 with surge chamber 23. As shown in Fig. 1, a filter 71 is provided in the sump 8 of crank case. Pressure in the crank case substantially corresponds to suction pressure since the suction manifold is connected to the crank case. Pressure in crank case 7 forces oil from sump 8 through lines 25 and capillary tube 24 to surge chamber 23. Thus, as pressure in crank case 7 varies in accordance with changes in load as denoted by change in suction pressure, the change in liquid pressure imposed upon bellows 63 is retarded due to the surge chamber 23 and capillary tube 24.

It will be appreciated that the surge chamber is trapped so that refrigerant gas is always present therein. The capillary tube 24 retards the flow of oil into and from the surge chamber 23. The pressure in the surge chamber is a function of oil level (x). As level rises pressure increases and as level falls pressure decreases which results in the pressure imposed in one side of bellows 63 lagging behind the pressure change in crank case 8 and therefore lagging behind the change in suction pressure due to load change.

In normal operation, oil from pump 15 passes through line 17 to the inlet connection of valve 16. Dependent upon the position of piston 51 in chamber 50, certain of the outlets 58 are supplied with oil at full pressure, such oil being conducted by lines 19 to the power elements 14. Oil in chamber 50 passes through opening 57 into chamber 56. Chamber 56 is connected by means of line 21 to control valve 20. After valve port 65 in valve 20 is open, oil is free to pass through port 67 into the crank case, through outlet 69 and line 26.

Assuming port 65 of valve 20 is open, its effective area is approximately three times as great as the area of opening 57 in valve 16. When port 65 is open, the oil pressure in chamber 56 is reduced to approximately 10% of full oil pressure. When valve member 66 moves to restrict port 65 in response to change in load conditions reflected by a change in liquid pressure substantially equivalent to suction pressure, oil pressure in chamber 56 increases. When port 65 is closed completely, oil pressure in chamber 56 increases to the full supply pressure from the lubrication system. As the control oil pressure in chamber 56 varies in response to the movement of needle 66 in valve 20, piston 51 moves abruptly to open or to close outlets 58 in sequence. The application or removal of oil pressure to or from the various power elements 14 operates the unloading mechanism 12 to unload or to load the various compressor cylinders.

As pointed out above, movement of needle 66 depends upon the pressure imposed upon bellows 63, such pressure being the oil pressure imposed through surge chamber 23 as pressure in crank case 7 varies depending upon change in load. Such change in pressure is not reflected immediately in chamber 23 due to capillary tube 24. Assuming the pressure increases, then it is necessary that the refrigerant gas contained in surge chamber 23 be compressed to a greater degree before such change in load is reflected by movement of needle 66, thereby delaying or retarding the transmission of the pressure change to the control valve 20. Likewise, if the pressure in crank case 7 decreases due to decrease in load, pressure in surge chamber 23 is such that it need be reduced to permit the control valve to reflect this decrease in load thereby again imposing a time delay in response of valve 20.

It will be appreciated chamber 23 is placed within the compressor housing in order that it may be maintained at approximately the same temperature as the crank case to ensure a supply of refrigerant gas in the surge chamber at all times.

The manner in which capillary tube 24 is connected to sump 8 of crank case 7, provides some advantages since it ensures that the pressure on the opposite side of the oil filter is slightly less than actual crank case pressure. This connection may be made, however, at any place in the crank case below the oil level.

While in the construction described a capillary tube is employed in connection with the surge chamber, it will be understood other types of restrictions or orifices may be used in place thereof.

The arrangement described provides a capacity control arrangement for a reciprocating compressor in which sufficient time delay in response of the control instrument is provided to prevent rapid recycling. The invention is simple and may be included at slight expense in the control arrangement. The time delay so provided is automatic in operation and does not require care by an operator. As the refrigeration system is

always filled with refrigerant when oil is added to the compressor, refrigerant gas is always present in the surge chamber.

What we claim is:—

1. A capacity control for a reciprocating compressor, comprising a fluid pressure actuated element for holding a compressor valve in inoperative position, fluid pressure actuated means for permitting or discontinuing the passage of fluid to said element, means responsive to load conditions for varying the fluid pressure imposed on the fluid pressure actuated means to permit or to discontinue the passage of fluid to said element in accordance with load conditions, and a control for retarding the response of said means to changes in load conditions, said retarding control comprising a trapped surge chamber, means including a restricted orifice connecting the chamber with a source of oil pressure which varies in accordance with changes in load, e.g., the crank case of the compressor below the oil level therein, and a line connecting the surge chamber with the load responsive means to actuate the same.

2. A capacity control according to Claim 1, wherein the means responsive to load conditions is subjected to fluid pressure substantially equivalent to the suction pressure of the compressor.

3. A capacity control according to Claim 1 or Claim 2, in which the means connecting the chamber with a source of oil pressure comprises a capillary tube.

4. A capacity control according to any of Claims 1-3, in which a pump is provided to supply lubricant to moving parts of the compressor and a line connects the pump to the sump of the compressor, the means which include the restricted orifice being connected to said line.

5. A capacity control according to Claim 3 or 4 wherein the surge chamber contains refrigerant gas.

6. A capacity control according to any of the preceding claims for a reciprocating compressor having two or more cylinders each having a fluid pressure actuated element in association therewith, the fluid pressure actuated means comprising a first valve permitting or discontinuing the passage of fluid to the elements of the two or more cylinders in sequence, and the load responsive means comprising a second valve for varying the fluid pressure imposed on the first valve.

7. A capacity control for a reciprocating compressor, constructed and arranged substantially as described and shown in the accompanying drawings.

8. A reciprocating compressor including a capacity control according to any of the preceding claims.

For the Applicants,
PAGE, WHITE & FARRER,
Chartered Patent Agents,
27, Chancery Lane, London, W.C.2.

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733,511 COMPLETE SPECIFICATION
1 SHEET
This drawing is a reproduction of the Original on a reduced scale.

FIG.1.

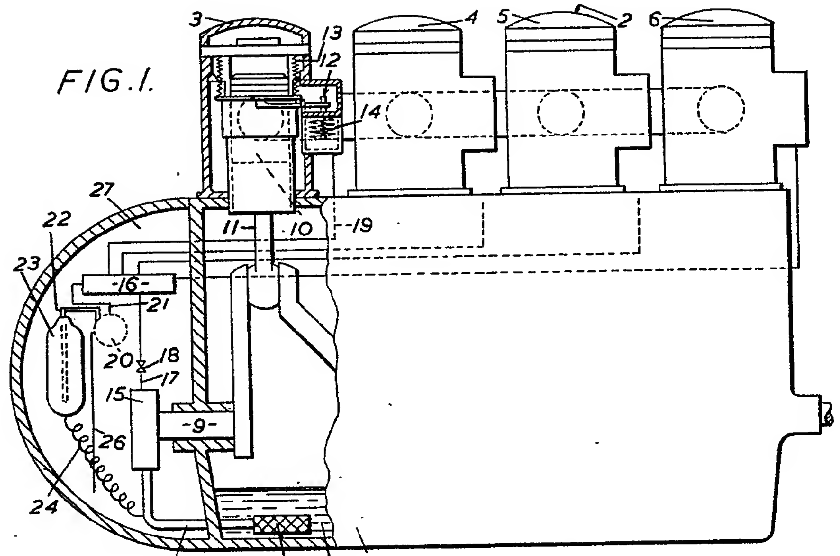

FIG.2.